

XI.—On some Tertiary Foraminifera from Borneo collected by Professor Molengraaff and the late Mr. A. H. Everett, and their Comparison with similar Forms from Sumatra. By R. BULLEN NEWTON, F.G.S., and RICHARD HOLLAND.

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INTRODUCTION.

(1) *Previous Work on the Tertiary Foraminifera of Borneo.*  
 —The presence of a Nummulitic formation in Borneo appears to have been first recognized by Dr. Schwaner in 1844 during his explorations in the southern part of the country (Riam Kiwa district), although the fact was not published until 1857\*, several years after his death.

C. de Groot † next refers to the same rocks as containing

\* Anon., "De Steenkolen in het rijk van Bandjermassin," Tijdsch. Nederl.-Indië, 1857, vol. ii. pp. 129-156 (from papers left by Dr. Schwaner, written about 1844).

† "Zuid- en Oosterafdeeling van Borneo," Nat. Tijdsch. Nederl.-Indië, 1857, vol. xiv. pp. 40-49.

Nummulites; but it was reserved for P. van Dijk \* in 1858 to first determine the forms and to identify them as of "Suessonien" age, the species being as follows:—*Nummulina depressa*, Orb., *N. lenticularis*, Bronn, *N. mamilla*, Höninghaus, and *N. polygyrata*, Deshayes.

A further reference to these Nummulites was made by C. de Groot † in a letter to Sir Roderick Murchison during 1863, a list of species being given which corresponded exactly with van Dijk's of 1858.

To Dr. R. D. M. Verbeek ‡ we are, however, indebted for the earliest published figures and descriptions of Bornean Foraminifera, issued in 1871. His specimens were obtained, also from the southern part of the island, at Riam Kiwa, Pengaron, &c., and were determined as *Nummulites pengaronensis* (sp. n.), *N. sub-Brongniarti* (sp. n.), *N. biaritzensis*, Archiac, and *N. striata*, Orb., var. *f* (var. nov.), *Orbitoides discus*, Rüttimeyer, *O. Pratti*, Michelin, *O. papyracea*, Orbigny, *O. Fortisi*, Archiac, &c., all of which were referred to the Eocene period.

In 1878 Dr. K. von Fritsch § made a further study of a similar series of forms from Southern Borneo, and described them as occurring in the Orbitoidenschichten division of the Eocene beds, under the following names:—*Nummulites sub-Brongniarti*, Verbeek, *Orbitoides papyracea*, Boubée, *O. ephippium?*, Schloth., *O. omphalus*, sp. n.?, and *O. decipiens*, sp. n.?

In 1882 Prof. K. Martin || identified *Orbitoides dispansa* and *Nummulina* in the Teweh district and near Martapura (S. Borneo) as of probably Eocene age; but such forms as *Cycloclypeus*, *Rotalia*, *Globigerina*, *Orbitoides*, *Textularia*, and *Amphistegina*, which came from Tungang, on the River Barito, of South Borneo, he regarded as Miocene. Dr. T. Posewitz ¶ next referred to the Foraminifera found near

\* "Over der Waarde van eenige Nederlansch-Indische Kolensoorten," Nat. Tijdsch. Nederl.-Indië, 1858, vol. xv. pp. 139-158.

† "Notes on the Mineralogy and Geology of Borneo and the adjacent Islands," Quart. Journ. Geol. Soc. 1863, vol. xix. p. 515.

‡ "Die Nummuliten des Borneo-Kalksteines," Neues Jahrbuch, 1871, pp. 1-14, pls. i.-iii.; "De Nummulieten uit den Eoceenen Kalksteen van Borneo," Jaarb. Mij. Ned. O.-Indië, 1874, vol. ii. pp. 133-161, plate (= reprint of the 1871 paper).

§ "Einige Eocäne Foraminiferen von Borneo," Palæontographica, 1878, Suppl. vol. iii. pp. 139-143, pls. xviii., xix.

|| "Neue Fundpunkte von Tertiär-Gesteinen im Indischen Archipel; nach Sammlungen von Horner, Korthals, Macklot, Müller [und Reinwardt]," Samml. geol. Reichs-Museums Leiden, 1882, pp. 132-147.

¶ "Geologische Notizen aus Central-Borneo (Das Tertiäre Hügelland bei Teweh)," Nat. Tijdsch. Nederl.-Indië, 1884, vol. xliii. pp. 169-175.

Teweh (Central Borneo) as being similar to those described by Verbeek from the Pengaron district.

Mr. A. V. Jennings \*, in 1888, contributed an interesting account of the Orbitoides composing the Silungen and Batu Gading limestones of Northern Borneo, from material supplied him by Mr. H. T. Burls, F.G.S., identifying the following forms:—

- Orbitoides (Discocyclina) papyracea*, Boubée.  
 — (—) *applanata*, Gümbel.  
 — (—) *ephippium*, } J. de C. Sowerby.  
 — (—) *dispansa*, }  
 — (*Asterocyclina*) *stellata*, Gümbel.

The author particularly notes the absence of *Nummulites* in these limestones, and regards the species enumerated as indicative of a later date than Eocene.

A valuable report was issued by Dr. M. von Hantken † in 1889 on an examination of some rocks from Batu-Bangka, South Borneo, in which the following specimens, referred to an Upper Eocene age, were identified:—

*Orbitoides dispansa*, Sby., *O. papyracea*, Boubée, *Heterostegina* (like) *reticulata*, Rüttimeyer, *Nummulites* (rare), *Rotalia*, *Globigerina*, *Bolivina*, *Pulvinulina*, *Clavulina cylindrica*, Hantken, = *C. rudislosta*, sp. n., *Gaudryina Reussi*, Hantken, *Chilostomella cylindroides*, Reuss, *Marginulina subbullata*, Hantken, *Cassidulina globosa*, Hantken, *Globigerina bulloides*, Orb., *G. triloba*, Reuss, *Pseudotruncatulina Dutemplei*, Orb., *P. propinqua*, Reuss, *Plecanium*, &c.

Dr. J. W. Retgers ‡, in 1895, records the occurrence of Foraminifera (*Nummulites* and *Orbitoides*) in different limestones obtained from localities on the east coast of Borneo, but without reference to their geological age.

(2) *The late Mr. A. H. Everett's Specimens.*—The late Mr. A. H. Everett §, a few years since, presented to the

\* "Note on the Orbitoidal Limestone of North Borneo," Geological Magazine, 1888, pp. 530-532, pl. xiv.

† Included in Dr. T. Posewitz's 'Borneo,' 1889, pp. 383, 384 (published in Berlin); see also English translation of this work by F. H. Hatch, 1892, p. 491.

‡ "Mikroskopische Beschrijving van Gesteenten afkomstig van de Oostkust van Borneo," Jaarb. Mijn. Nederl. Oost-Indië, 1895, vol. xxiv. pp. 78-98.

§ Mr. Everett died in London on the 13th of June, 1898, after spending the greater part of his life in Borneo. He was a clever naturalist and collector, having identified himself with the avifauna of the country besides becoming an authority on its geology in connexion with mineral

British Museum a series of limestone specimens which he collected in various parts of Borneo during a long residence in that island, with a request that the organisms contained in them might be examined, so that a satisfactory conclusion might be arrived at respecting their probable geological age. It was found on examination that these specimens were divisible into two distinct groups—one Mesozoic, the other Tertiary. The former series, already referred to by one of us\* in a published communication, included limestones obtained from localities in the western end of the Sarawak province on or near the river of the same name, which were largely composed of coral, bryozoan and sponge structures, and regarded as belonging to the Middle Oolite division of the Jurassic system.

The Tertiary limestones, containing the Foraminifera now about to be described, were collected in two widely distant regions of Borneo, some being found in the Malinam River (a tributary of the River Baram), which flows between the limestone-mountains of Molu and Barib, near the boundary of the Brunei and Sarawak divisions of the country; whilst the remainder were obtained from Gomanton Hill, in the Kina-batangan district, north-east of the island, a locality much celebrated for some rich guano-deposits which are worked there.

From their occurrence in a river-bed the Malinam-River limestones are naturally rounded and waterworn; when cut and polished, or if their external surfaces are merely wetted, they are found to contain numerous Foraminifera, as well as calcareous algæ (*Lithothamnium*) &c.

In these limestones we have determined the following specimens:—

- Nummulites javanus*, Verbeek. Forms A and B;
- Orbitoides* (*Lepidocyclina*) *Verbeeki*, sp. n.;
- (——) *sumatrensis*, Brady;
- (*Discocyclina*) *stellata*, Archiac;

and other *Discocyclines*, *Cycloclypeus*, and many *Milioline* and *Rotaline* forms.

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distribution and the origin of the limestone-caves. On these subjects he contributed several papers to the scientific journals. His loss will be greatly felt by all those interested in the natural history of Borneo.

\* R. B. Newton, "On a Jurassic Lamellibranch and some other associated Fossils from the Sarawak River Limestones of Borneo; with a Sketch of the Mesozoic Fauna of that Island," *Geol. Mag.* 1897, pp. 407-415.

The Gomanton-Hill rock is a cream-coloured limestone, much less crystalline than that from the Malinam River, and containing a small percentage of phosphate (information kindly given us by Mr. G. T. Prior, of the British Museum). So far as our examination has gone, we have observed no Nummulites in this limestone, its structure yielding *Orbitoides* (*Lepidocyclina*) *sumatrensis*, Brady, *Linderina*, sp., together with numerous forms of Miliolines and Rotalines.

(3) *Professor Molengraaff's Specimens*.—Professor Molengraaff's specimens were obtained during his expedition to Central Borneo in the years 1893 and 1894, of which a geographical notice \* and a preliminary geological report † have already been published.

In his account of the fossils, however, Dr. Krause excludes all consideration of the Radiolaria and Nummulites, specially stating that the former were under description by Dr. G. J. Hinde and the latter by Professor Schlumberger (see p. 170 of Krause's paper).

When Professor Molengraaff visited the British Museum in the spring of 1897 he requested one of the present writers to undertake an examination of his Bornean Foraminifera, mentioning at the time that they had been placed before Professor Schlumberger, of Paris, who had been obliged to return them unidentified on account of their very imperfect preservation. The specimens and microscopical preparations were therefore duly forwarded to the British Museum from the Laboratory of Mineralogy at Amsterdam ‡, an examination of which proved the presence of *Nummulites Djokdjokarte*, K. Martin, a species common to the Oligocene rocks of Sumatra and Java, occurring in boulder no. 985; *Discocyclina*, a subgenus of *Orbitoides*; and possibly *Amphistegina*.

The Molengraaff material is in the form of boulders mostly composed of a coarse quartz conglomerate, although the largest (nos. 984 and 986, in two pieces) is of somewhat different structure, being more of the nature of a grey felspathic grit, with intercalated lustrous black patches of a carbonaceous substance. Throughout this mass foraminiferal remains are

\* G. A. F. Molengraaff, "Die Niederländische Expedition nach Zentral-Borneo in den Jahren 1893 u. 1894," Petermann's 'Mittheilungen,' 1895, vol. xli. p. 201.

† P. G. Krause, "Ueber Tertiäre, Cretaceische und ältere Ablagerungen aus West-Borneo," Samml. geol. Reichs-Mus. Leiden, 1897, vol. v. ser. 1, p. 169.

‡ This was effected through the kindness of Mrs. Molengraaff, her husband having started for Pretoria to take up his new position of State-Geologist to the South African Republic.

fairly abundant, being rather more easily discernible near the outer surface, where they occur as reddish-brown casts, considerably decomposed. Two microscopical sections have been made from boulder no. 984, which is a matrix of black colour and crowded with Nummulites. None of the other boulders having been fractured, we are unable to say anything respecting their internal characters.

All the boulders were obtained from the river-beds of Embalau, Tekelan, and Sajang, offshoots of the great Kapuas River in its uppermost regions, being numbered as follows under a group termed Series I. :—

- No. 982. River Tekelan.  
 983. River Embalau (right bank),  $\frac{1}{2}$  kilom. below R. Sajang.  
 984. River Embalau.  
 984. )  
 985. ) River Tekelan.  
 986. )  
 987. )

The distinguishing numbers on the microscopical sections are :—

V. 1648 & V. 1650, made from Boulder no. 984.

V. 1644, V. 1645, V. 1646, and V. 1647, made from Boulder no. 986.

(4) *Age of the Specimens.*—In determining the geological horizons of the specimens described in this paper we have been mainly guided by the carefully worked out results of the Javan Foraminifera as set forth in Verbeek and Fennema's important monograph entitled 'Description géologique de Java et Madoura.' The authors mentioned have limited *Orbitoides* to two subgenera instead of five as originally proposed by Gümbel, viz. *Discocyclina* and *Lepidocyclina*, characteristic of different parts of the Tertiary system. As we show later on, Messrs. Verbeek and Fennema hold that *Discocyclina*, having simple rectangular chambers in the median plane, as found in the Indian Archipelago, belongs entirely to Eocene and Oligocene rocks; whereas *Lepidocyclina*, with rounded chambers, never occurs in this area in older deposits than Miocene, and apparently becomes extinct during Pliocene times. Similarly with regard to the Nummulites we can recognize an Eocene and Oligocene age respectively for *Nummulites javanus* and *N. Djokdjokarta*, species found both in Borneo and Java.

The foregoing considerations would lead us to conclude that the Malinam-River pebbles may be referred to two periods—(1) an Eocene, determined by the presence of

*Nummulites javanus* and *Orbitoides (Discocyclus) stellata*; and (2) a Miocene or Pliocene, characterized by *Orbitoides (Lepidocyclus) Verberki* and *O. (L.) sumatrensis*.

Again, the Gomanton-Hill limestone would appear to represent a Miocene or Pliocene age, on account of its structure exhibiting forms of *Orbitoides (Lepidocyclus) sumatrensis*; and, lastly, the "Molengraaff" boulders from West-central Borneo, in which we have identified *Nummulites Djokdjokarte* and *Orbitoides (Discocyclus)*, may be regarded as belonging to the Oligocene formation.

Tertiary Foraminifera are widely distributed over the islands of the Indo-Pacific area; and although our knowledge is more complete concerning those forms found in Sumatra, Java, and Borneo, we are not without evidence of their occurrence in Timor \*, Celebes \*, the Philippines †, and eastwards to New Guinea ‡. Moreover at Christmas Island, some 200 miles south of Java, Mr. C. W. Andrews § has recently discovered limestones containing *Orbitoides* and other Foraminifera underlying a comparatively recent coral-formation. These limestones, when properly investigated, will add a new interest to the geology of this region.

Before concluding this introductory portion of our work, some acknowledgments are due to those friends who have assisted us in the preparation of this paper. To Mr. H. W. Burrows we are greatly indebted for the careful microphotographs he has produced of our slides, the negatives of which he has generously allowed us to use for our illustrations on the present occasion; we have also to thank Mr. Burrows for his otherwise kindly help and interest shown us during our examination of the Bornean rocks. We wish to tender our thanks to Dr. Harmer for the loan of that portion of Brady's type material from Sumatra which is preserved in the University Museum of Zoology at Cambridge, the remainder being in the British Museum at South Kensington. Our

\* K. Martin, "Palæontologische Ergebnisse von Tiefbohrungen auf Java, nebst allgemeineren Studien über das Tertiär von Java, Timor, und einiger anderer Inseln," Samml. geol. Reichs-Mus. Leiden, 1887, vol. iii. no. 15, p. 310 (Timor), p. 362 (Celebes).

† F. von Richthofen, "Ueber das Vorkommen von Nummulitenformation auf Japan und den Philippinen," Zeitschr. deutsch. geol. Ges. 1862, vol. xiv. p. 357.

‡ K. Martin, "Eine Tertiärformation von Neu-Guinea und benachbarten Inseln," Samml. geol. Reichs-Mus. Leiden, 1881, vol. i. no. 2, p. 72.

§ Information contained in an Address read before the Royal Geographical Society, November 28th, 1898, and published in 'The Geographical Journal' for January 1899; see also Geol. Mag. 1899, January, no. 415, p. 25.

thanks are also due to Professor Molengraaff for granting us the privilege of studying his interesting specimens from West-central Borneo. Finally we may state that our studies of the "Everett" limestones have been greatly facilitated by the excellent microscopic sections prepared for us by Mr. Richard Hall, the assistant-formatore of the British Museum at South Kensington.

## DESCRIPTION OF THE FORAMINIFERA.

### (A) NUMMULITES.

#### 1. *Nummulites javanus*, Verbeek, form B. (Pl. IX. figs. 1, 2, 3.)

*Nummulites javanus*, vars. A (*soloensis*), B, C, D, Verbeek, "Voorloopig Bericht over Nummulieten, Orbitoiden en Alveolinen van Java &c.," Nat. Tijdschr. v. Nederl.-Indië, 1891, vol. li. pp. 105, 106, figs. 1, 2, 3; R. D. M. Verbeek and R. Fennema, Desc. géol. Java et Madoura, 1896, vol. i. pl. iii. figs. 45-57, pl. iv. figs. 58-68, pl. v. figs. 69-73, and pl. vii. fig. 94, vol. ii. p. 1143 *et seq.*

Shell lenticular; edge somewhat obtuse; one surface more convex than the other; sometimes the shell in vertical section appears plano-convex or even concavo-convex; the majority of the vertical sections show a slight sigmoidal curvature; surface probably smooth, but none of our specimens have been obtained free from the matrix. The "columns," however, do not pass up through the vertical section sufficiently strongly to produce tubercles upon the surface, though there might be slight external markings. The "filets cloisonnaires," or alar prolongations of the septa, are subreticulate, and are well shown in horizontal section in Pl. IX. fig. 3. This figure is strictly comparable with figs. 67 and 68 in plate iv. of Verbeek's work mentioned above; and it will be seen from our figure that "les piliers sont grenus en coupe," as Verbeek describes them in his Javan specimens.

The mean dimensions of the Bornean specimens are 20 millim. in diameter by 4 millim. in thickness; but in all, or nearly all these specimens, the actual size must have been somewhat greater, because the external surface of the shells has suffered more or less corrosion in the process of fossilization. There are about 26 turns of the spiral in a radius of 10.5 millim. and 16 chambers in  $\frac{1}{4}$  turn at a radius of 5 millim. The coiling is, however, irregular. The chambers differ considerably in size even in the same convolution, though not to the extent apparently shown in Pl. IX. fig. 2. That figure is deceptive, as all thin sections of *Nummulites* cut on the



horizontal plane must be, because no strictly horizontal plane will exactly pass through the middle of every chamber in the median section. The central chamber is invisible.

These large Nummulites are undoubtedly identical with one or other of the four varieties of *N. javanus* described by Dr. Verbeek, and the species is closely related to the well-known *N. levigata* of Europe. Dr. Verbeek may be cited in support of this view as to the affinities of the species. He describes as *N. levigata* one of his Javan Nummulites, and goes on to say (*op. cit.* p. 1152):—"La seule différence entre cette espèce et la *N. levigata* d'Europe (notamment telle que Carpenter la décrit et la représente dans le Quart. Journ. of the Geol. Soc. vol. vi. 1850, pl. iii. fig. 2, car la description et les figures de cette espèce par d'Archiac ne sont pas toujours exactes), c'est l'aspect plus ponctué de la surface et le nombre un peu plus considérable des tours de spire pour une même rayon. . . . Notre espèce a aussi beaucoup d'analogie avec le *N. javanus* var.  $\delta$ , tant pour le nombre des tours de spire que pour celui des loges, de sorte qu'il faut peut-être la considérer comme une 5<sup>e</sup> variété de notre *N. javanus* à cloisons moins arquées et à piliers plus épais."

The figure by Carpenter to which Dr. Verbeek refers above is that of a *N. levigata* from the Bracklesham Beds in Sussex, which differs very considerably from the typical *N. levigata* of the Paris Basin and Belgium—differs, in fact, as widely as other Nummulites which have been ranked as separate species. *N. javanus* departs from the typical *N. levigata* in a somewhat opposite direction, but hardly perhaps more widely. That the Bornean specimens are very close allies of *N. levigata* is further shown by their association with a form having a large initial chamber and bearing a strong resemblance to *N. Lamarcki*, the European companion of *N. levigata*.

This association of Nummulites, first indicated by Messrs. Parker and Jones (*Ann. & Mag. Nat. Hist.* ser. 3, vol. viii. 1861, p. 233), is a very well-known phenomenon. Every student of these fascinating organisms is aware that Nummulites almost always, if not invariably, occur in pairs of so-called "species." One of the members of the couple is generally larger than its fellow, and has always a very minute or even invisible initial chamber, while the other member, which never attains a large size, is distinguished by the possession of a comparatively large initial chamber. Each member of such a couple has been looked upon as a distinct species, and has been named accordingly. The propriety of the distinction has been questioned by several authors, but

the general view of writers on Nummulites has been that expressed by the diverse nomenclature. Of late years, however, considerable attention has been given to the study of the initial and immediately succeeding chambers of the shells of the Foraminifera, and notably by MM. Schlumberger, Munier-Chalmas, and Van den Broeck. Mr. J. J. Lister, too, has closely studied the life-history of *Polystomella*, a genus nearly allied to *Nummulites*. The result of the researches of these and other observers \* is to show that many species of Foraminifera are dimorphic, and it seems to be probable, in the light of Mr. Lister's observations, that the coupled forms of Nummulites represent alternate generations of one species. In any case it seems to be desirable that the nomenclature should express relationship between the companion forms, and it appears that there is more advantage, in the present state of our knowledge, in considering paired forms as varieties of one species than as specifically distinct. We therefore, following the rule of M. Schlumberger as regards other Foraminifera, designate this large form with minute initial chamber *N. javanus*, form B, and the smaller companion with large initial chamber *N. javanus*, form A.

2. *Nummulites javanus*, Verbeek, form A.  
(Pl. IX. figs. 4 & 5.)

*Nummulites baguelensis*, Verbeek (pars), Nat. Tijdsch. Nederl.-Indië, 1891, vol. li. p. 107; Description géologique de Java et Madoura, 1896, vol. i. pl. iii. fig. 75, pl. vi. figs. 81-85, vol. ii. p. 1148.

Shell lenticular; regularly swollen at the centre; edge obtuse; surface probably smooth; "filets cloisonnaires" subreticulate. The mean dimensions of our specimens are 3.2 millim. in width by 1.8 millim. in thickness, but these measurements are probably rather less than the actual for the reason given in the description of the form B. The number of convolutions is usually 4 or 5. We have not found in our preparations any good horizontal sections, but we have enough to show that the size and irregular shape of the initial chamber, the generally semilunar shape of the first succeeding chamber, the dimensions of the chambers in the spire, and the closing-in of the later convolutions constitute a

\* Bull. Soc. Géol. France, sér. 3, vol. viii. 1880, p. 300; Comptes Rendus, vol. xcvi. 1883, pp. 862-866 and pp. 1598-1601; Ann. & Mag. Nat. Hist. ser. 3, vol. xi. 1883, pp. 340, 341; Bull. des Séances de la Soc. roy. Malacol. de Belgique, 1893, tom. xxviii.; Phil. Trans. vol. 186, 1895, pp. 401-453; Proc. Camb. Philosophical Soc. 1897, vol. ix. part 5, pp. 236-240. See also T. R. Jones, Ann. & Mag. Nat. Hist. 1894, ser. 6, vol. xiv. pp. 401-407.

strong resemblance to the characters of *N. Lamarcki*, the European companion of *N. levigata*. *N. javanus*, form A, differs from *N. Lamarcki* chiefly in its fewer convolutions and its rather more robust habit of growth.

Here and there in the same slides with *N. javanus*, form A, we have met with vertical sections of rather smaller Nummulites less robustly built than their companions and with the initial chambers measuring .12 millim. in width. We are inclined to think that these Nummulites are variants of *N. javanus*, form A, corresponding to the variety of *N. Lamarcki* figured by d'Archiac and Haime in pl. iv. fig. 16 of their monograph.

*Occurrence.* *N. javanus* (both forms) occurs in our material only in two pebbles from the bed of the River Malinam. In one pebble particularly it occurs in great profusion.

### 3. *Nummulites Djokdjokartæ*, K. Martin (sp.).

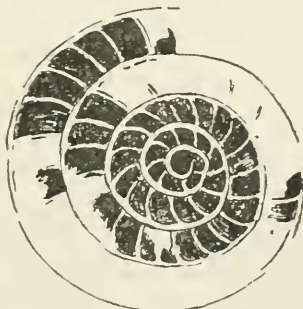
*Nummulites Lamarcki*, R. D. M. Verbeek, "Tertiärformation von Sumatra," Palæontographica, 1880, Suppl. 3, Lief. 8, Theil 1, p. 23 (non Archiac and Haime).

*Nummulina Djokdjokartæ*, K. Martin, "Tertiär-Versteinerungen vom östlichen Java," Samml. geol. Reichs-Mus. Leiden, 1881, no. 2, p. 110, pl. v. figs. 9-11.

*Nummulites Jogjakertæ*, R. D. M. Verbeek, "Voorloopig Bericht over Nummulieten, Orbitoiden en Alveolinen van Java, &c.," Nat. Tijdschr. v. Nederl.-Indië, 1891, vol. li. pp. 116, 117, figs. 1-3 on plate.

*Nummulites Jogiakartæ*, R. D. M. Verbeek and R. Fennema, Description géologique Java et Madoura, 1896, vol. i. pl. viii. figs. 114-119, vol. ii. p. 1152.

To this species we refer certain specimens which occur in the material collected by Prof. Molengraaff. This material, as



*Nummulites Djokdjokartæ*, K. Martin (sp.).  
(Magnified 12 times.)

already stated, consists of small boulders and a few microscopic sections cut from two of them. On chipping one of

the boulders (no. 984) specimens of *N. Djokdjokartæ* in a very decayed condition are here and there met with. The specimen figured measured 3·5 millim. in width and the central chamber measured ·28 millim. The number of convolutions was 4 or  $4\frac{1}{2}$ , and the number of chambers in the spire was about 64. The thickness of the specimen (judging from the cast in the matrix) appears to have been from 1 to 2 millim.

Prof. Molengraaff's slides contain various more or less obscure sections of Nummulites. Some of them are possibly referable to this species, others possibly belong to an alternate form of the same or to distinct species; but they do not happen to be cut so as to enable us to determine their characters. One of these indeterminate sections is shown in Pl. IX. fig. 6.

*Occurrence.* Prof. Molengraaff's material was obtained from the beds of the Rivers Embalau and Tekelan.

### (B) ORBITOIDES.

In the Appendix to the valuable work on the Geology of Java and Madoura already referred to Dr. Verbeek gives a very interesting chapter on the Orbitoides met with. He reviews much of the work of other writers upon the genus, and expresses himself in favour of reducing Gumbel's\* five subgenera to two—that is to say, he would unite *Discocyclina*, *Rhipidocyclina*, *Aktinocyclina*, and *Asterocyclina* under the subgenus *Discocyclina*, comprising all Orbitoides having rectangular chambers in the median plane; and for the second subgenus he would retain Gumbel's *Lepidocyclina*, comprising the Orbitoides with rounded chambers in the median plane. We quite agree in this arrangement. It appears to us that the division into subgenera on the basis of the characters of the chambers of the median plane is likely to give satisfactory results, while divisions based on the external form or ornamentation of the shells, such as "*Rhipidocyclina*," "*Aktinocyclina*," and "*Asterocyclina*," must lead to confusion. We say this particularly because in the study of our Bornean material we have come across fragments which, while they are not sufficiently perfect for description, give us good ground for expecting that specimens will presently be met with having the external form of Gumbel's *Asterocyclina*, for instance, coupled with the lozenge-shaped or spatuliform median chambers which are characteristic of *Lepidocyclina*.

We think it not improbable that the *O. (Asterocyclina) stellata* figured by Vaughan Jennings in his paper on the

\* "Beitrage zur Foraminiferen-Fauna der nordalpinen Eocengebilde," Abhandl. k. Bayer. Akad. Wiss. Classe ii. Band x. (1868).

Orbitoidal Limestone of North Borneo (Geol. Mag. dec. iii. vol. v. 1888, pl. xiv. fig. 7) may belong to the Lepidocycline rather than the Discocycline group.

Dr. Verbeek ventures to put forth an important generalization based on his study of the Orbitoides of Java and the neighbouring lands. He writes:—"Dans toutes les couches, caractérisées comme éocènes par la présence de nummulites et d'alvéolines, il existe de nombreuses discocyclines (y compris des rhipido-, des actino- et des astéro-cyclines), mais pas une seule lépidocycline. Par contre, dans les milliers de plaques microscopiques de roches de Java et de Sumatra, qui d'après leurs mollusques doivent appartenir au terrain *tertiaire supérieur*, je n'ai rencontré que des lépidocyclines et jamais je n'y ai observé une seule discocycline." (*Op. cit.* p. 1164.)

So far as our observations go they tend to confirm this generalization of Dr. Verbeek. In the sections cut from the pebbles taken from the bed of the River Malinam we find associated with Nummulites a few vertical sections of Orbitoides. We have not been able to discover in our slides any sections showing the chambers of the median plane, but the general appearance of the sections leads us to look upon the Orbitoides as Discocyclines rather than Lepidocyclines. On the other hand, in our sections containing undoubted Lepidocyclines we find no trace of Discocyclines, and Nummulites are altogether absent, though we have met with one or two rather obscure sections of *Amphistegina*.

#### 4. *Orbitoides (Lepidocyclina) Verbeeki*, sp. n. (Pl. IX. figs. 7-11; Pl. X. fig. 1.)

*Orbitoides papyracea*, Brady, Geol. Mag. 1875, pl. xiv. fig. 1, p. 535 (non Boubée).

*Lepidocyclina* species *g* and *h*, Verbeek and Fennema, Descr. géol. de Java et Madoura, 1896, vol. i. pl. xi. figs. 173-175, 177-180, vol. ii. p. 1178.

In the volume of the 'Geological Magazine' referred to above the late Dr. Brady described and figured certain Orbitoides and other Foraminifera from Sumatra. The specimens were supplied by Dr. Verbeek, and they are now preserved partly in the British Museum (Nat. Hist.) and partly in the University Museum of Zoology at Cambridge. Certain of the Orbitoides were referred by Dr. Brady to *O. papyracea*, Boubée, and were so figured in the plate xiv. illustrating his paper. *O. papyracea*, Boubée, however, belongs to Gümbel's subgenus *Discocyclina*, having the chambers of the median plane rectangular; but Brady's Sumatran specimens have the chambers of the median plane

“en losange,” as Dr. Verbeek has already pointed out merely from an examination of fig. 1c in Brady’s plate; and they are therefore properly to be referred to the subgenus “*Lepidocyclina*,” which is characterized by the possession of non-rectangular chambers in the median plane.

In order to clear up as far as may be the proper relationships of Brady’s species we have carefully examined the numerous free specimens, now in the British Museum, which Dr. Brady had before him when writing his paper; and by the kindness of Dr. Harmer, of the University Museum of Zoology at Cambridge, we have been enabled thoroughly to examine the actual figured and other prepared specimens used by Brady to illustrate his paper.

We have no hesitation in saying that Brady’s Sumatran specimens are identical with a species which occurs frequently in our slides cut from one of the pebbles taken from the bed of the River Malinam; and we agree with Dr. Verbeek that they are identical also with the species *g* and *k* figured in plate xi. of his work already several times referred to.

So far as we can see the specimens fall under no species already described—and here we are in agreement with Dr. Verbeek—and we therefore describe it as a new species under the designation *Orbitoides (Lepidocyclina) Verbeeki*. As the Sumatran specimens which we have been able to study are perfect, numerous, and quite free from matrix, we have preferred to figure for the most part preparations of those rather than our Bornean sections. Fig. 9 of Pl. IX., however, is from one of our slides.

*Characters.* The species is dimorphic—that is to say, some individuals have the initial chamber large, while in others it is very small, practically invisible. They are distinguished here as form A and form B respectively.

Form A.—Shell discoidal, regularly swollen at the centre; surface smooth and devoid of ornament; edge very slightly thickened and rounded; initial chamber large and apparently always succeeded by a chamber still larger and partly embracing the first; chambers of the median plane lozenge-shaped, the chamber-walls being slightly curved; chambers above and below the median plane irregular in shape, but somewhat regularly disposed. External dimensions of shell 5 to 6 millim. in width by 1·5 to 2 millim. in thickness; inside dimensions of the two central chambers taken together about ·5 millim. in width by ·25 millim. in depth; chambers of median plane very minute; long axis of lozenge about ·09 millim.

The external appearance of a typical specimen is well

shown in fig. 1 of Pl. X. Fig. 7 of Pl. IX. shows the vertical section and fig. 8 the chambers of the median plane; while a horizontal section cutting the chambers above the median plane is given in fig. 10.

Form B.—Shell discoidal, regularly swollen at the centre; surface smooth and devoid of ornament; edge thin and more extended than in form A; initial chamber invisible; some specimens appear to show a spiral arrangement of the first few chambers; chambers of the median plane lozenge-shaped and similar in appearance and dimensions to the corresponding chambers of form A; chambers above and below the median plane also similar to those of form A. External dimensions of the shell 10 to 12 millim. in width by about 2 millim. in thickness; some individuals may considerably exceed in size the width here given, because the thin edge of the specimens we have examined is generally more or less broken. The chambers of the median plane of form B are shown in Pl. IX. fig. 11.

*Occurrence.* The specimens of *O. (Lepidocyclina) Verbeeki* in the British Museum and in the University Museum of Zoology at Cambridge were collected by Dr. Verbeek in Sumatra. Dr. Verbeek's species "*g*" came from the "Marne près d'Hilihoïa, île de Nias, côte occidentale de Sumatra"; the species "*k*" was obtained from the "Calcaire de Boukit Ngareh ou Pouangang, à Batoumëndionlour, hauts plateaux de Padang, côte occidentale de Sumatra." Our Bornean specimens are from pebbles found in the bed of the River Malinam.

5. *Orbitoides (Lepidocyclina) sumatrensis*, Brady.  
(Pl. X. figs. 7-12.)

*Orbitoides sumatrensis*, Brady, Geol. Mag. 1875, p. 536, pl. xiv. fig. 3;  
and Jaarb. Mij. Ned. Ooste-Indië, 1878, vol. vii. pt. 2, pl. ii. fig. 3,  
p. 165.

This species was first described by Brady in the paper on the Sumatran Foraminifera published in the Geol. Mag. as above. We reproduce here the material part of Brady's note:—"There are still some two or three little fossils pertaining to the genus *Orbitoides*. They are subglobular or only slightly compressed, 3 millim. in diameter and about 2·5 millim. in thickness. The exterior is rough and granular. Laid horizontally, there is an irregular partial extension of the periphery, which seems to suggest an abortive disc. It is within the bounds of possibility that these specimens may be the central thick portions of some form like the more umbonate varieties of *O. dispansa*, but the interior structure

does not lend itself to this supposition. The general arrangement of the chamberlets is shown in fig. 3 *c*, which is drawn from a horizontal section near, but not at, the median plane. A transverse section shows the median disc, which does not appear to be quite uniformly central in its position, exceedingly thin in the middle, thickening rapidly towards the circumference, rounded at the margin, and having somewhat the contour in section of an hourglass drawn out a little at the ends. The primordial chamber, as far as can be made out, is very small."

In our Pl. X. figs. 7 and 8 we figure again the specimens illustrated by Brady in the 'Geological Magazine.' Brady's figures were drawn by A. Hollick, ours are from photographs of the actual specimens, and simply demonstrate the accuracy of the original drawings. In fig. 10 we give Brady's preparation (not before figured) on which he appears to have based his description of the transverse section of the shell. It is clear that this figure does not represent a vertical section, but one taken at a considerable angle with the vertical.

An example of *O. sumatrensis* in the British Museum (Nat. Hist.) collection has been ground down in order to discover the true characters of the chambers of the median plane (Pl. X. fig. 9). In thus operating upon this specimen we were able to note the appearance of the horizontal sections at various stages and also sections at slight angles with the horizontal. We have thus been enabled to recognize that numerous orbitoid sections in our slides cut from the limestone of Gomanton Hill and from one of the pebbles from the bed of the River Malinam are to be properly referred to this species; and we venture to give the characters of the species as follows:—

*Characters.* Shell subglobular; about 3 millim. in width by 1.5 to 2.5 millim. in thickness; exterior rough and granular; median edge produced to form a narrow keel; median chambers variable in size and shape, but always rounded or "spatuliform." Chambers above and below the median plane have the shape of shallow cylinders and are remarkably constant in size and regular in arrangement; chamber-walls finely perforate. The initial chamber of the British Museum specimen was "megalospheric" (about .5 millim. in diameter); the Cambridge specimen (Pl. X. fig. 10) is possibly, as Brady supposed, "microspheric." If so, we have both form A and form B of the species.

The general external appearance of the shell is shown in Pl. X. fig. 7, photographed from Brady's figured specimen.



Fig. 8 is photographed from Brady's horizontal section cut "near, but not at, the median plane." It and fig. 10 show well the cylindrical shape of the chamberlets and the perforate chamber-walls. Fig. 6 shows the shape of the chambers of the median plane, and figs. 1 and 3 (from our Bornean material) give vertical sections of the shell.

*Occurrence.* Brady's specimens were collected by Dr. Verbeek from the marl-rock of Nias Island, west coast of Sumatra. Our specimens are from the Gomanton-Hill limestone and from pebbles taken from the bed of the River Malinam.

6. *Orbitoides (Discocyclina) stellata* (d'Archiac).  
(Pl. X. fig. 2.)

*Calcarina? stellata*, d'Archiac, "Desc. Foss. Couches Nummulines environs Bayonne," Mém. Soc. Géol. France, 1846, sér. 2, vol. ii. pt. 1, pl. vii. fig. 1, p. 199.

*Orbitoides (Asterocyclina) stellata*, Gümbel, "Beitr. Foram. nordalpinen Eocängebilde," Abhandl. k. Bayer. Akad. Wiss. 1868, Classe ii. Band x. p. 713, pl. ii. fig. 115, pl. iv. figs. 4-7.

To this species probably belongs the specimen figured in Pl. X. fig. 2. We have some hesitation in naming the specimen at all, and do so only because of its association in our slides with *Nummulites javanus* and because we find that, so far as our study of the Sumatran and Bornean material goes, Dr. Verbeek's generalization as to the non-occurrence of Lepidocycline *Orbitoides* in association with *Nummulites* appears to hold good.

*Occurrence.* In a pebble from the bed of the River Malinam.

7. Other *Orbitoides*.  
(Pl. X. figs. 3 & 4.)

In our slides cut from pebbles of the River Malinam in which *Nummulites* occur there are a considerable number of sections (more or less vertical) of *Orbitoides*. They probably belong to the subgenus *Discocyclina*, and possibly include *O. (Discocyclina) papyracea*, Boubée, and *O. (Discocyclina) dispansa*, Sowerby. One of the vertical sections we figure in Pl. X. fig. 3.

In the material collected by Prof. Molengraaff one section, probably of a *Discocycline*, has been met with; this we figure in Pl. X. fig. 4.

## (C) LINDERINA\*.

8. *Linderina*, sp. indet. (Pl. X. fig. 6.)

In our slides cut from the Gomanton-Hill limestone numerous sections of specimens of this interesting genus occur, but there are not a sufficient number of good sections to enable us to refer them specifically.

The characters of the genus, as given by M. Schlumberger, are as follows:—

“Plasmostracum discoïdal surépaissi au centre, composé d'un seul rang de nombreuses petites loges disposées circulairement autour d'une loge centrale et dans un même plan. Les parois de chaque série de loges se prolongent vers le milieu au-dessus des loges déjà formées. Cette enveloppe calcaire est traversée par de fortes perforations qui pénètrent directement jusqu'aux loges internes.”

One species only is known, namely *L. brugesi*, Schlumberger, which comes from the Upper Eocene of Bruges (Gironde).

## (D) CYCLOCYPEUS.

9. *Cyclocypeus*?, sp. indet. (Pl. X. fig. 5.)

The remarkable specimen figured as above is probably to be referred to this genus. It occurs in one of the pebbles from the bed of the River Malinam associated with *Nummulites javanus*, forms A and B. The actual shell was probably at least twice the width of the fragment preserved, and presumably had the shape of a thin disk with a central swelling and two or more concentric thickened bands. The published figure which appears to have the closest resemblance to it is that of *Cyclocypeus annulatus*, Martin (Tertiärsch. Java, 1879-80, p. 157, pl. xxviii. fig. 1).

## (E) OTHER FORAMINIFERA.

10. *Miliolina*, *Spiroloculina*?, *Planispirina*, &c.

Our slides cut from the pebbles of the Malinam River and from the Gomanton-Hill limestone contain numberless sections of other Foraminifera belonging to the genera *Miliolina*,

\* C. Schlumberger, “Note sur les Genres *Trillina* et *Linderina*,” Bull. Soc. Géol. France, 1893, sér. 3, vol. xxi. pl. iii. figs. 7-9, p. 120.

*Spiroloculina*?, *Planispirina*, and to the subfamily Rotalinæ; but we have not thought it worth while to attempt to refer such to particular "species," since we have nothing but sections cut in more or less indeterminate directions.

## EXPLANATION OF THE PLATES.

## PLATE IX.

*Nummulites javanus*, Verbeek. Form B.

- Fig. 1. Vertical section,  $\times 3$ . (B. M.)  
 Fig. 2. Horizontal section,  $\times 10$ . (B. M.)  
 Fig. 3. "Filets cloisonnaires,"  $\times 10$ . (B. M.)

*Nummulites javanus*. Form A.

- Fig. 4. Vertical section,  $\times 15$ . (B. M.)  
 Fig. 5. Ditto,  $\times 10$ . (B. M.)

*Nummulites*, sp. indet.

- Fig. 6. Vertical section,  $\times 12$ . (M.)

*Orbitoides (Lepidocyclina) Verbeeki*, sp. n. Form A.

- Fig. 7. Vertical section,  $\times 13$ . (C.)  
 Fig. 8. Horizontal section on median plane,  $\times 20$ . (B. M.)  
 Fig. 9. Ditto,  $\times 30$ . (B. M.)  
 Fig. 10. Horizontal section above median plane,  $\times 13$ . (C.)

*Orbitoides (Lepidocyclina) Verbeeki*. Form B.

- Fig. 11. Horizontal section on median plane,  $\times 25$ . (B. M.)

## PLATE X.

*Orbitoides (Lepidocyclina) Verbeeki*. Form A.

- Fig. 1. Exterior,  $\times 9$ . (C.)

*Orbitoides (Discocyclina) stellata*, d'Archiac.

- Fig. 2. Section approximately horizontal and above median plane,  $\times 20$ . (B. M.)

*Orbitoides (Discocyclina)*, spp. indet.

- Fig. 3. Vertical section,  $\times 12$ . (B. M.)  
 Fig. 4. Ditto,  $\times 25$ . (M.)

*Cycloclypæus*?, sp. indet.

- Fig. 5. Section,  $\times 11$ . (B. M.)

*Linderina*, sp. indet.

- Fig. 6. Vertical section,  $\times 30$ . (B. M.)

*Orbitoides (Lepidocyclina) sumatrensis*, Brady.

Fig. 7. Exterior,  $\times 9$ . (C.)

Fig. 8. Horizontal section above median plane,  $\times 30$ . (C.)

Fig. 9. Chambers of median plane,  $\times 60$ . (B. M.)

Fig. 10. Oblique section,  $\times 35$ . (C.)

Fig. 11. Vertical section,  $\times 16$ . (B. M.)

Fig. 12. Ditto,  $\times 25$ . (B. M.)

Note.—The capital letters within brackets have the following signification:—

B. M. = British Museum collection.

M. = Professor Molengraaff's collection.

C. = Cambridge Museum of Zoology collection.

### XLI.—*The Outcome of a South-Sea Voyage* \*.

By L. A. BORRADAILE.

DR. ARTHUR WILLEY was engaged on a voyage of research in the South Seas from 1895 to 1897. Since his return his valuable material has been in the hands of specialists, and the results of their labours are to be embodied in a work at present appearing in parts from the Cambridge University Press. The first two of these parts are now before us.

It is quite clear that, however valuable be the papers by other contributors, the explorer's own communications will form the prominent feature of the series.

This is amply evident in the first number, in which by far the most important article is the opening one by Dr. Willey on a new species and subgenus of *Peripatus* from New Britain. In accordance with the territorial nomenclature adopted for many species of the genus, the new form is to be called *Peripatus (Paraperipatus) novæ-britanniæ*. The male of this creature has 22 pairs of legs and the female, which is larger and more numerous, has 24. There are three spinous pads on each leg, and the generative opening is placed immediately behind the last pair. Receptacula seminis are present in the female, but there are no receptacula ovarum. The eggs are small and without yolk. The accessory glands of the male open to the exterior through a median bulbus immediately above the anus. The ductus ejaculatorius is median and short, and spermatophores are not formed.

\* 'Zoological Results, based on material from New Britain, New Guinea, Loyalty Islands, and elsewhere, collected during the Years 1895, 1896, and 1897.' By Arthur Willey, D.Sc. Lond., Hon. M.A. Cantab., Balfour Student of the University of Cambridge. Parts I. and II. Cambridge: at the University Press, 1898.